DRRC Industrial Demand Response Technical Advisory Group Meeting

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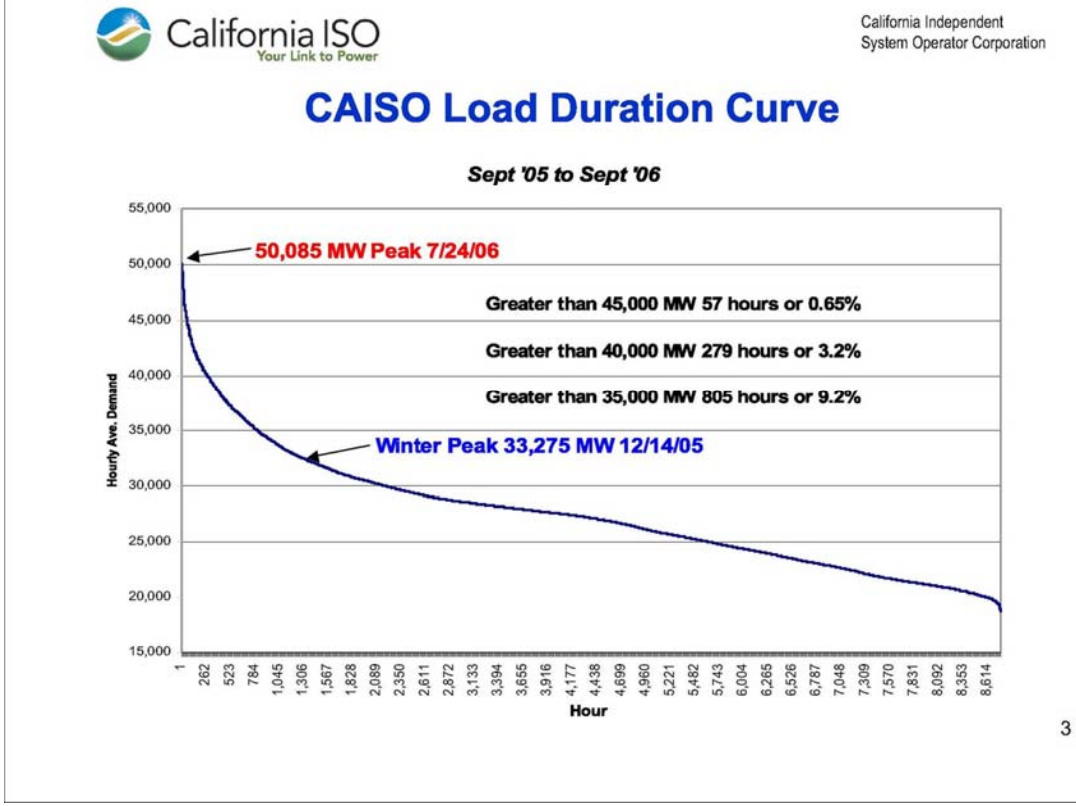
Demand Response Research Center

Presentation Overview

- Definitions and Background
- DRRC Industrial Research Goals
- Key Research Questions
- Overview of First Year Research and Results
- Industrial DR Database Analysis
- Barriers
- Key Findings
- Proposed 2008 Research

What is Demand Response?

- A set of actions taken to reduce electric loads when:
  1. Contingencies, such as emergencies or congestion, occur that threaten the supply-demand balance OR
  2. Market conditions occur that raise electric supply costs
- The goal is to improve electric grid reliability and lower use of electricity during peak demand



DRRC Research Areas

- **Energy Systems and Strategic Issues**
  - Valuing Demand Response
  - Dynamic Tariffs and Rate Design
  - Communications Infrastructure
- **Buildings**
  - Automation, Communications and Control
  - End-Use Control Strategies and Models
  - Behavior – consumer response to dynamic tariffs and DR
- **Industry**
  - Automation, End-Uses and Controls
- **Sponsor**
  - California Energy Commission Public Energy Research Program

Automation Goals and Definition

Recent Research Goals

- **Cost** - Develop low-cost, automation infrastructure to improve DR capability in California
- **Technology** - Evaluate "readiness" of buildings to receive signals
- **Capability** - Evaluate capability of control strategies for current and future buildings

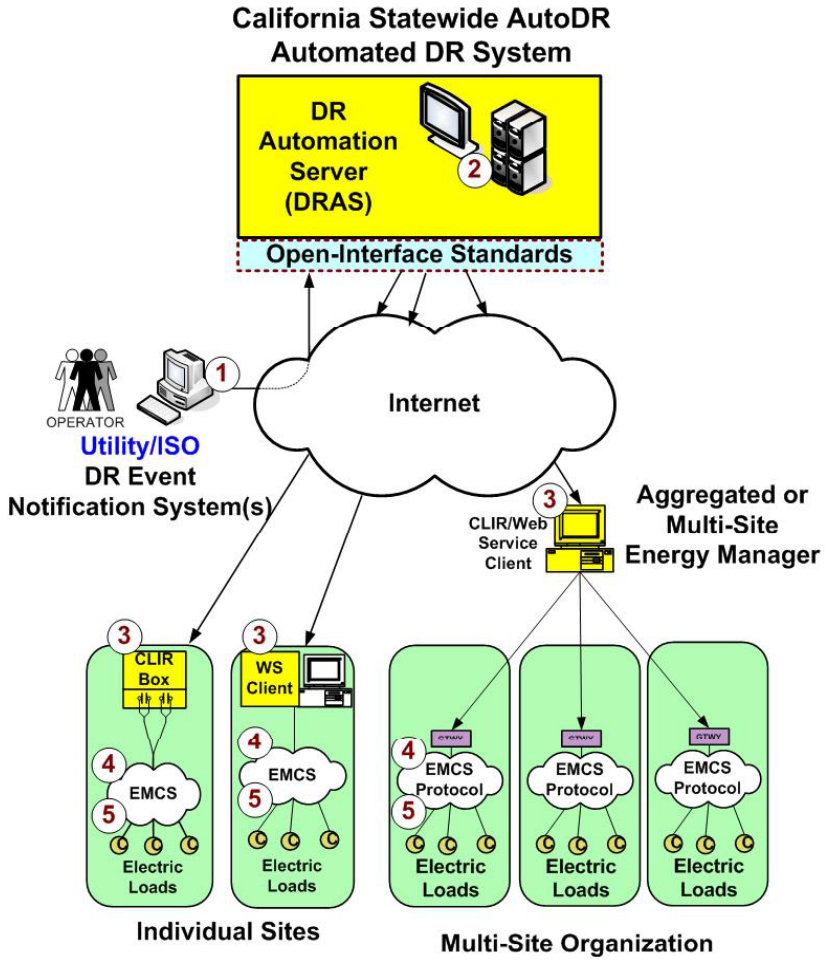
Auto-DR Definition - Fully automated signal for end-use control

- **Signaling** – Continuous, secure, reliable, 2-way communication with listen and acknowledge signals
- **Industry Standards** - Open, interoperable standard control and communications to integrate with both common EMCS and other end-use devices that can receive a relay or similar signals (such XML)
- **Timing of Notification** - Day ahead and day of signals are provided to facilitate a diverse set of end-use strategies

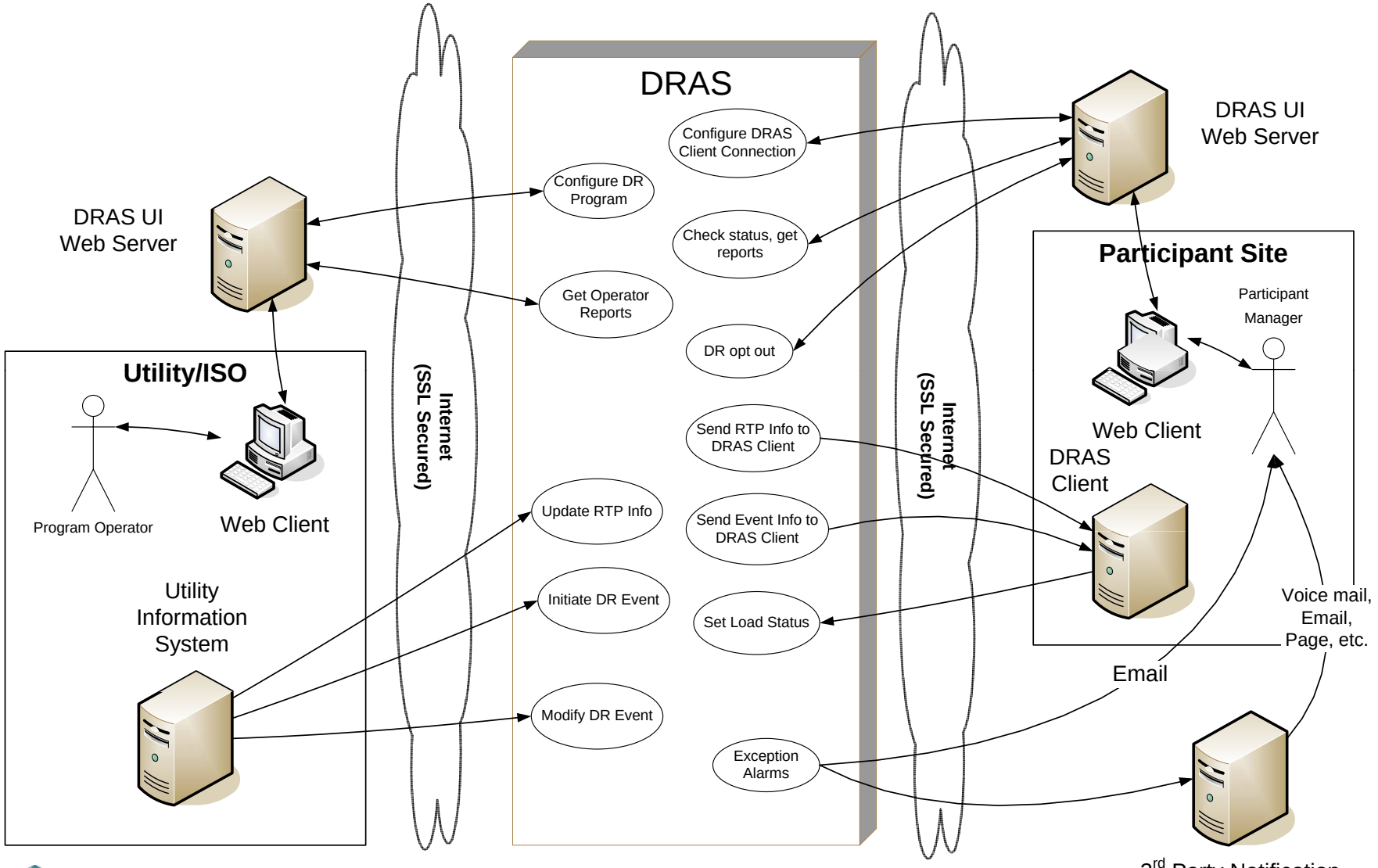
How does Auto-DR work?

1. The Utility or ISO defines DR event and price/mode signals are sent to DRAS.
2. DR event and price services published on DRAS.
3. DRAS Clients (CLIR or WS) request real-time event data from DRAS every minute.
4. Customized pre-programmed DR strategies determine action based on event price/mode.
5. Facility Energy Management Control Systems (EMCS) or related controls carry out load reduction based on DR event signals and strategies.

Typical Auto-DR Open-Interface Architecture



DR Automation Server Event Architecture



DR Framework for Industrial Facilities

	Demand-Side Management		
	Efficiency and Conservation (Daily)	**Peak Load Management (Daily)**	**Demand Response (Dynamic Event Driven)**
Motivation	- Utility Bill Savings - Environmental Protection	- TOU Savings - Demand Charge Savings - Grid Protection	- Price - Reliability - Emergency - Grid Protection
Design	- Efficient Production and Support Equipment & Systems	-Low Power Design	- Dynamic Control Capability for Production and Support Systems
Operations	- Integrated Support System Operations - Optimized Production System Operations	- Demand Limiting - Demand Shifting	- Demand Shedding - Demand Shifting - Demand Limiting
Initiation	Local	Local	Remote

Initiating Industrial DR Research at DRRC

Lead: Aimee McKane

- 25+ years of experience in energy efficiency policy, program design, and analysis
- 12 years exclusively in industrial energy efficiency, both US and internationally, especially China
- Major clients: US Department of Energy, United Nations Industrial Development Organization, California Energy Commission, International Energy Agency
- Most recently worked for California Public Utilities Commission as the convenor for industry for 2009-2020 Statewide Energy Efficiency Strategic Plan

Industrial Team formed in October 2006 to begin research on Auto-DR

Goals for DRRC Industrial DR Research

- Our primary research goal to facilitate deployment of automated demand response (Auto-DR) in industry that is *economically attractive and technologically feasible*
- Auto-DR:
  - Is a set of standard, continuous, open communication signals and systems provided over the Internet
  - Allows facilities to pre-determine and automate their demand response with “no human in the loop”
- Auto-DR has been tested successfully in over 50 commercial buildings during the past 4 years

Advantages of Industrial Auto-DR

Automating demand response will make industrial DR:

- More *visible* by providing greater transparency through two-way end-to-end communication allowing Internet tracking of DR signals received from end-use customers;
- More *repeatable, reliable, and persistent* because DR signals trigger fully automated controls strategies that are "hardened" and pre-programmed into facility's software and hardware;
- More *affordable* because automation can help reduce labor costs associated with manual DR strategies initiated by facility staff and can be used for long-term.

Purpose of the Industrial DR TAG

1. Represent a variety of stakeholders, including industry, consultants to industry, utilities, state government, academia, ESCOs
2. Provide review and comment on the work of the DRRC Industrial Demand Response Team
   - Initial request to review 2007 Year End Report summarizing the Industrial Team's work to date
3. Contribute to the planning process for future work

Goal:

Assist the DRRC in defining issues and needs for supporting more widespread DR participation by industrial facilities

Key Research Questions

1. What are the electricity use and electricity use patterns of specific industrial sectors as they relate to DR potential?
2. What is the potential for manual or Auto-DR shed or shift strategies within and across sectors?
3. How does the existing industrial controls environment either support or impede this potential?
   a. What are market trends in industrial controls technology and applications?
   b. How can these trends be strengthened to increase the feasibility for DR, especially Auto-DR?
   c. What are technology gaps that might benefit from public R&D?

Key Research Questions, con't

4. What is the "migration potential" for DR strategies in promoting industrial load management and energy efficiency in industrial facilities, and vice versa?
5. What are barriers to implementation of reliability and price-responsive industrial DR?
   a. How can DR event notification to industrial facilities be managed for maximum effectiveness?
   b. What roles do price and incentives have in decision making
      - For small, non-disruptive sheds or shifts?
      - For larger sheds or shifts?
   c. What are areas of potential tension between price responsive DR and the industrial plant work force (in terms of total hours or shift worked)?

Previous Research

- Conducted a literature search to evaluate key questions and current knowledge
- Key Resources
  1. Quantum Consulting and Summit Blue Consulting for Southern California Edison and Working Group 2 Measurement and Evaluation Committee. 2006. *Evaluation of 2005 Statewide Large Nonresidential Day-Ahead and Reliability Demand Response Programs*
  2. EPRI for California Energy Commission. 2005. *Demand Response Analysis and Tool Development for Industrial, Agricultural, and Water (IAW) Energy Users*
  3. Goldman, C. and N. Hopper, et al. 2004. *Does Real-Time Pricing Deliver Demand Response? A Case Study of Niagara Mohawk's Large Customer RTP Tariff*. LBNL-54974
  4. York, Dan and Martin Kushler. 2005. *Exploring the Relationship Between Demand Response and Energy Efficiency: a Review of Experience and Discussion of Key Issues*. ACEEE #U052

Overview of First Year Research

Research activities included:

- A literature search of prior experiences with industry participation in interruptible demand response programs
- Preliminary analysis of electricity use and electricity use patterns in CA industries
- Preparation of an Industrial Demand Response Strategic Roadmap
- Creation and analysis of data in the Utility Audit Demand Response Database to identify potential DR shed and shift strategies

Overview of First Year Research, con't

Research activities included:

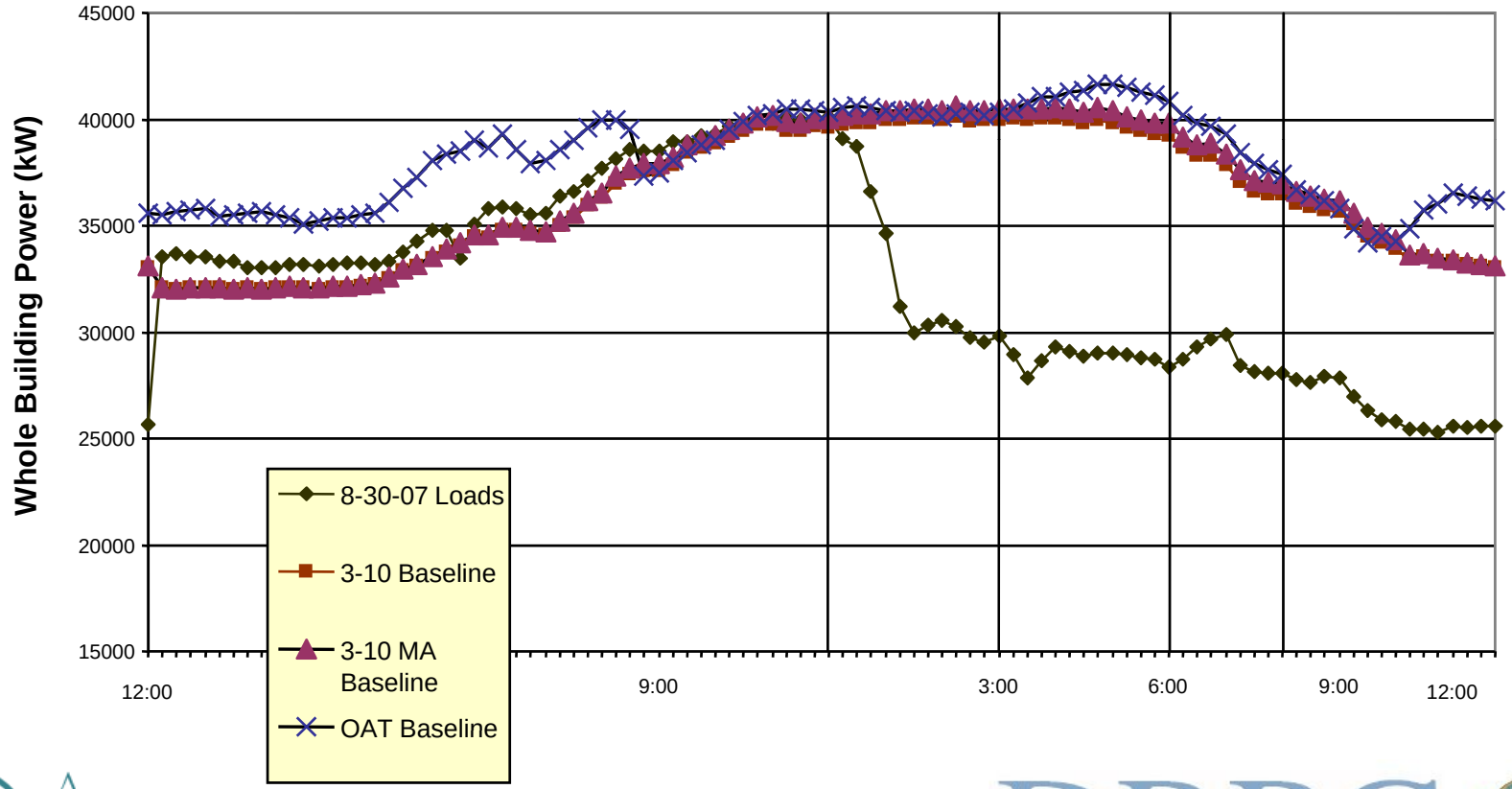
- Analysis of potential barriers to industrial participation in Auto-DR
- Collaboration in PG&E territory on Auto-DR recruitment and implementation for the 2007 season
- Analysis of sub-metering to monitor DR at six industrial facilities
- Summary of results of scoping studies undertaken to gain a better understanding of the food processing and semiconductor industries

Accomplishments

- Collaboration with PG&E and Global Energy Partners resulted contributed to15 MW AutoDR identified for implementation in 2007;
  - Created a site questionnaire
  - Developed two informational pieces on Auto-DR (data centers, general industrial)
- Additional sites still under consideration for research demos
- Increased understanding of potential motivation and barriers
- Developed and refined database of 207 energy audits
  - Analysis of database summarized in 2007 Year End Report
  - Prepared written recommendations to PG&E concerning improving the data collection process for integrated audits.

Auto-DR Implementation

CPP and Test Demand Bidding Event Participation on August 30, 2007



Statewide Results of Auto-DR Implementation (updated results)

CPUC ACR Objectives	2006	2007 Installed	2007 In-Process	2007 Total
1. Accelerate Implementation				
▪ Commercial participants	13	141	0	154
▪ Industrial participants	0	5	6	11
▪ Peak Load Reduction	1 MW	25 MW	2 MW	28MW
2. Expand Auto-DR beyond CPP to other DR options	CPP only	CPP, DBP, CBP		
3. Expand the role of Technical Providers	none	8 industry participants		
4. Improve DR performance (Peak Reduction)				
▪ Commercial	13%	20%	NA	20%
▪ Industrial	--	52%	54%	52%
▪ Aggregate All Participants	--	33%	54%	33%

Industrial DR Database Analysis

Industrial Demand Response Potential by 4-Digit NAICS (Top 25 by Average kW); n=207

		DR kW Potential	
4-Digit NAICS Code	NAICS Description, 2007	Sum	Ave
3211	Sawmills and Wood Preservation	3598	1799
2123	Nonmetallic Mineral Mining and Quarrying	2582	1291
3222	Converted Paper Product Manufacturing	1133	1133
5417	Scientific Research and Development Services	2693	898
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	4403	881
3331	Agriculture, Construction, and Mining Machinery Manufacturing	1729	865
3251	Basic Chemical Manufacturing	1868	623
3359	Other Electrical Equipment and Component Manufacturing	1750	583
3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Ma	1091	546
4529	Other General Merchandise Stores	523	523
3115	Dairy Product Manufacturing	1011	506
1151	Support Activities for Crop Production	490	490
3364	Aerospace Product and Parts Manufacturing	943	472
3329	Other Fabricated Metal Product Manufacturing	768	384
3116	Animal Slaughtering and Processing	744	372
3149	Other Textile Product Mills	303	303
3312	Steel Product Manufacturing from Purchased Steel	598	299
2213	Water, Sewage and Other Systems	7441	286
3118	Bakeries and Tortilla Manufacturing	1106	277
1121	Cattle Ranching and Farming	1018	255
3121	Beverage Manufacturing	2436	244
3221	Pulp, Paper, and Paperboard Mills	240	240
3271	Clay Product and Refractory Manufacturing	440	220
3339	Other General Purpose Machinery Manufacturing	633	211
4931	Warehousing and Storage	1045	209

Industrial DR Database Analysis

Comparison by 4-Digit NAICS Category: Top Electricity Consuming Manufacturing Industries and Industrial DR Potential from Audit Database Top 25 Industries by Average kW

Table 1		Table 4	
3344	Semiconductors & Electronics	3211	Sawmills and Wood Preservation
3261	Plastic Products	2123	Nonmetallic Mineral Mining and Quarrying
3241	Petroleum & Coal Products	3222	Converted Paper Product Manufacturing
3251	Basic Chemicals*	5417	Scientific Research and Development Services
3341	Computers & Peripherals	3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
3364	Aerospace Products	3331	Agriculture, Construction, and Mining Machinery Manufacturing
3121	Beverages	3251	Basic Chemical Manufacturing*
3273	Cement & Concrete	3359	Other Electrical Equipment and Component Manufacturing
3115	Dairy Products	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers & Filaments
3114	Canned & Frozen Foods	4529	Other General Merchandise Stores
3342	Communication Equipment	3115	Dairy Product Manufacturing
3254	Pharmaceuticals & Medicines	1151	Support Activities for Crop Production
3345	Navigation & Control Instruments	3364	Aerospace Product and Parts Manufacturing
3222	Paper Products	3329	Other Fabricated Metal Product Manufacturing
3272	Glass	3116	Animal Slaughtering and Processing
3279	Other Nonmetal Minerals	3149	Other Textile Product Mills
3231	Printing	3312	Steel Product Manufacturing from Purchased Steel
3118	Bakeries & Tortillas	2213	Water, Sewage and Other Systems
3323	Structural Metals	3118	Bakeries and Tortilla Manufacturing
3116	Meat Packing	1121	Cattle Ranching and Farming
3391	Medical Equipment	3121	Beverage Manufacturing
3329	Other Fabricated Metal Products	3221	Pulp, Paper, and Paperboard Mills
3328	Coating & Engraving	3271	Clay Product and Refractory Manufacturing
3332	Industrial Machinery	3339	Other General Purpose Machinery Manufacturing
3119	Other Foods	4931	Warehousing and Storage

* includes industrial gases

Industrial DR Database Analysis

Opportunities

- Leading opportunities for *production shifts* are:
  - conveyors,
  - all systems,
  - pump systems, and
  - electrical.
- For *production sheds*, the leading opportunities are:
  - all systems (stop production),
  - finishing,
  - process cooling and
  - pump systems.

Industrial DR Database Analysis

Opportunities

- Leading opportunities for *supporting system shifts* are:
  - space conditioning,
  - motors,
  - process cooling, and
  - storage.
- The leading *supporting systems shed* opportunities are:
  - aerators,
  - multiple systems,
  - electrical, and
  - compressed air.

Barriers to Auto-DR Adoption

- Lack of knowledge- DR opportunities in the industrial sector are still largely unidentified
- Incentives not commensurate with potential risk
- Facility managers rarely have a good grasp of the financial implications of DR participation
- Operations- industrial DR strategies may require some reorganization of production or shipping schedules
- Staff time constraints may preclude participating in non-automated industrial DR
- Missed DR event notification was a common problem identified by the 2005 Evaluation of non-automated industrial DR

Summary of Key Findings

- There appears to be great potential for Auto-DR in industrial facilities
- Further research is needed to understand
  1) organizational decision-making processes as they impact DR participation
  2) the role of existing and emerging industrial controls in contributing to the ability to readily participate in Auto-DR, and
  3) end-use process control capabilities to support reduced service and process control levels during DR events.

Key Findings- Detail

- Under the right conditions, some types of industrial facilities will shift or shed process load based on financial incentives, not just to protect reliability
- Auto-DR is entirely compatible with energy efficiency and load management in industrial facilities
- Many industries have limited controls capabilities, especially for supporting or peripheral systems that offer opportunity for Auto-DR.
  - There is an emerging market for demand management controls and system-level network controls that holds promise for Auto-DR.
  - One key feature of these controls is that they are integrated or centralized allowing the Auto-DR systems to be readily linked.
  - Dispersed controls have limited Auto-DR capability at this time.

Key Findings- Detail

- Current portfolio of industrial DR offerings is confusing and complex, but the availability of DR incentives and assistance can make participation attractive.
- With adequate data and industry input, a list of DR shed/shift strategies can be developed for a specific industrial sector
  - First list of potential strategies was developed in 2007 for data centers using industry input.
  - Based on integrated audit recommendations, we can begin to develop a “short list” of promising sectors to conduct further research on shift/shed strategies.
  - Additional data collection during integrated audits would accelerate this process.

Sectors Recommended for Further Study

1. Cold storage
2. Data centers and test labs for high tech industries
3. Aerospace products
4. Beverages, including breweries and wineries
5. Water/wastewater

Other areas of interest in include: paper products, plastics, dairy products (cheese), bakeries, cement, and electronics manufacturing

Example: Data Center Auto- DR Strategies

- Servers are grossly underloaded- 10-15% utilization rate is typical, so higher utilization rates would allow servers to be temporarily shut down
- This can be accomplished through:
  - Server consolidation software to increase the loading to 40% or more (one company is doing this as an energy efficiency measure, but it could be an Auto-DR measure for more risk-adverse centers)
  - Virtualization – segregating several tasks within one server
  - Task Prioritization – shutting down low-priority task servers.
  - Software (Cassatt, SUN, etc) already have this capability
- A longer term opportunity is geographic shifting where applicable; management issues that will need to be addressed to effectively use this type of software

Proposed 2008 Research

Task 1- Form and manage a Technical Advisory Group (TAG) to guide the work of the DRRC Industrial Team

Action Steps:

a. Develop a balanced list of Technical Advisory Group (TAG) invitees from industry, consultants, utilities, industrial trade associations, academia, and the state

b. Host 2-3 meetings/webcasts at LBNL

c. Communicate regularly with TAG members on the work of the DRRC Industrial Team

d. Engage TAG members in other tasks as appropriate

Proposed 2008 Research

Task 2- Conduct research on industrial controls capability/compatibility for Auto-DR

Our preliminary research has identified opportunities for research demonstrations and/or case studies in several areas:

- Adaptation of existing demand management software for Auto-DR applications;
- Minor modification to make network controls for supporting systems DR-enabled;
- Modification of Auto-DR software designed for energy efficiency and load management in data centers;
- Opportunities to “think beyond the plant” by bundling similar Auto-DR shed strategies into a single controls network so that sheds could be “tuned” to actual needs within the scope of individual participation agreements.

Proposed 2008 Research

Task 2 Action Steps

Proposed in 2008 to begin to address these opportunities:

a. Develop a survey of existing industrial control capabilities, to be administered via the web in cooperation with key industrial associations (California Manufacturers and Technology Association, California League of Food Processors, Silicon Valley Leadership Group, etc)
b. Draft discussion piece describing key control issues for successful implementation of Auto-DR
c. Host workshop of control experts from the demand response, demand management, and industrial system control communities to critique discussion piece and recommend a path forward
d. Draft white paper based on outcomes from the critique
e. Host 2-3 workshops with industrial associations to share the outcomes of the controls workshop and further refine white paper
f. Publish paper on the technical capacity for Auto-DR in CA industry
g. Investigate opportunities for /provide technical assistance to initiate demonstrations of DR-enabled controls as an integrated feature for original equipment manufacturers
    - Compressed air and pumping system networked controls
    - Virtualization/prioritization software for data centers
h. Develop case studies on demonstrations (complete in 2009)

Proposed 2008 Research

Task 3: Conduct further research on industrial energy use patterns in California, with the goal of identifying specific sheds and shifts in sectors previously identified as showing potential

Action Steps:

a. Continue to collect and analyze data from utility industrial integrated audits – goal of 100 additional audit records to database created in 2007

b. Continue to advise investor-owned utilities on methods to improve their audit data collection and reporting processes

c. Compare findings from Task 2 w/database analysis and refine results

d. "Drill down" in two sectors,refrigerated warehouses and data centers, to fine-tune understanding of DR and Auto-DR opportunities.
   - Conduct literature/web search, analyze the results of submetering, where applicable
   - Conduct analysis and field work, especially in cooperation with third-party utility contractors working in these sectors
   - Use results of analysis, additional utility audit database analysis, and field work to identify the DR potential of specific technology options
   - Prepare report on findings to use as the basis for development of a DR Strategy Guide for each sector

Proposed 2008 Research

Task 4: Work with utilities and their contractors to identify 2008 Auto-DR industrial participants

Action Steps:

- Participate in weekly conference calls, networking and referrals, developing and maintaining a prospect list, and site visits
- Apply results from Tasks 2 and 3 to refine technical assistance
- Conduct field assessments of Auto-DR
  - Efficacy of site questionnaire
  - Continue work with utilities on improved data collection and analysis
  - Follow-up measurement and analysis of sheds and shifts from sites recruited in 2007 as well as sites new in 2008
  - Develop case studies of successful participation (where permitted by site)
- Prepare report on findings
- Participate in training, including participating in and/or hosting PG&E InterAct and Auto-DBP technical coordinator training